SWAIN'S LAKE
1992
LAKES LAY MONITORING PROGRAM

by

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edited by

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NEW HAMPSHIRE LAKES LAY MONITORING PROGRAM

NH LLMP

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University of New Hampshire
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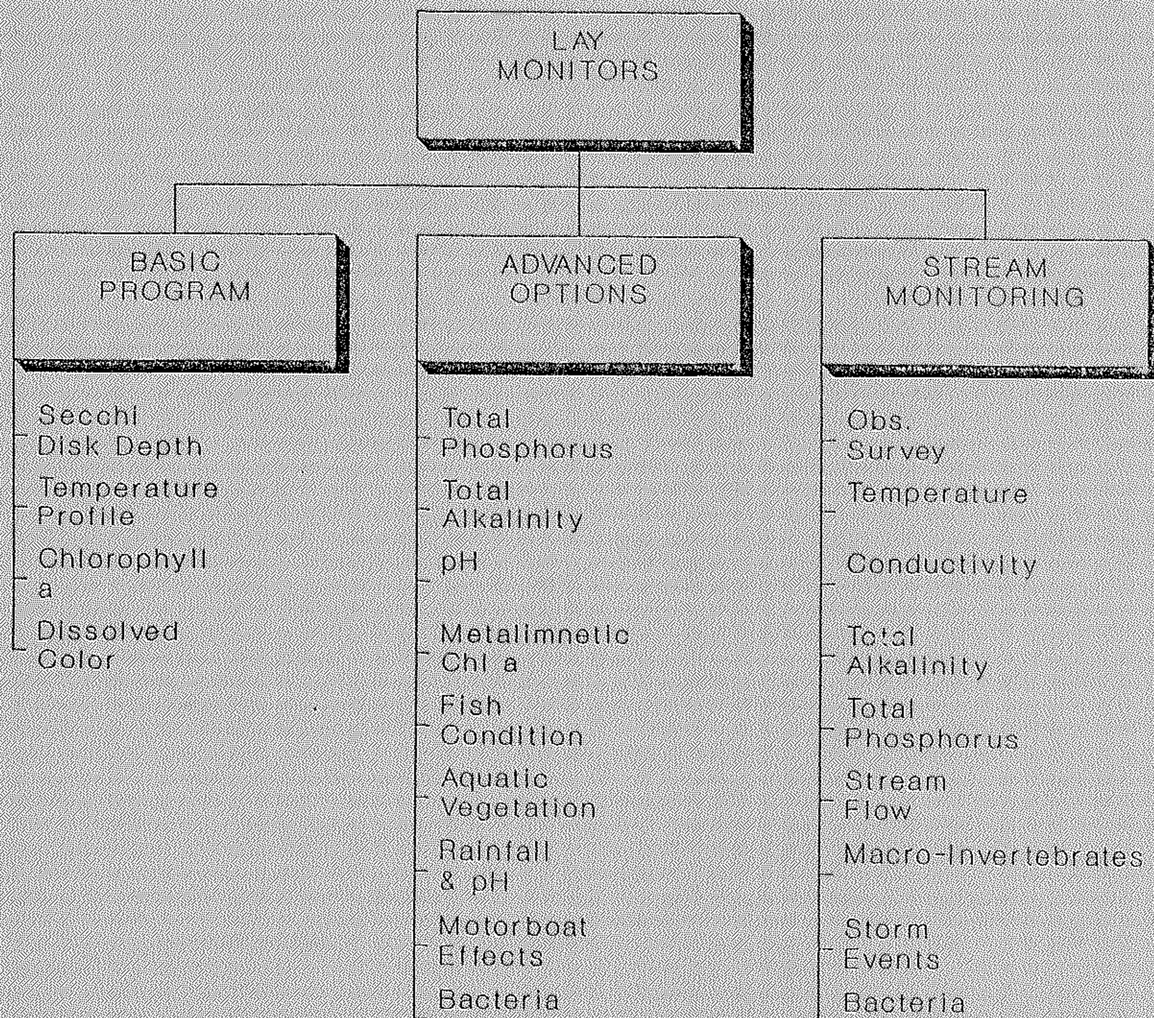

PREFACE

This report contains the findings of a water quality survey of Swain's Lake, New Hampshire, conducted in the summer of 1992 by the Freshwater Biology Group (FBG) of the University of New Hampshire and the Swain's Lake Association.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1992 results as well as more detailed "Introduction" and "Discussion" sections. Graphic display of data is included, in addition to listings of data in appendices, to aid visual perspective.

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ACKNOWLEDGEMENTS

This was the fourth year of participation in the Lakes Lay Monitoring Program (**LLMP**) for the Swain's Lake monitors. The Lay Monitors of the lake were Dwight and Natalie Brown, Pete Gaucher, Miriam Miner, Ken Sargent, Wendi Tremblay, Ed Sorel, H. Richmond and Peter and Carol Kevin. Carol Kevin again coordinated the volunteer monitoring efforts on Swain's Lake and acted as liaison to the FBG. The Freshwater Biology Group (**FBG**) congratulates the Lay Monitors on the quality of their work and the time and effort put forth. We encourage other interested members of the Swain's Lake Association to continue monitoring during the 1993 season. Funding for the monitoring program was provided by the Swain's Lake Association.

The Freshwater Biology Group is a not-for-profit research program co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the **FBG** summer field team included Jeffrey Schloss, Robert Craycraft, Gregg Vereb, Gregg Stevens, Sean Proll, Matt Denneen and Robert Banks. Other **FBG** staff assisting in the fall were Eric Betke, Amanda Fifield, Jessica Chappell and Phil Lucason.

The **FBG** acknowledges the University of New Hampshire Cooperative Extension for funding and furnishing office, laboratory and storage space. The College of Life Sciences and Agriculture provided accounting support and the UNH Office of Computer Services provided computer time and data storage allocations.

Participating groups in the **LLMP** include: The New Hampshire Audubon Society, Derry Conservation Commission, Dublin Garden Club, Nashua Regional Planning Commission, Center Harbor Bay Conservation Commission, Governor's Island Club Inc., Little Island Pond Rod and Gun Club, Walker's Pond Conservation Society, United Associations of Alton, the Pemaquid Watershed Study Group, the associations of Baboosic Lake, Beaver Lake, Berry Bay, Big Island Pond, Bow Lake Camp Owners, Chesham Pond, Lake Chocorua, Crystal Lake, Cunningham Pond, Dublin Lake, Glines Island,

Goose Pond, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Lovell Lake, Marchs Pond, Mascoma Lake, Mendum's Pond, Meredith Bay Rotary Club, Merrymeeting Lake, Milton Ponds Lake Lay Monitoring, Mirror Lake (Tuftonboro), Moultonbouro Bay, Lake Winnipesaukee, Naticook Lake, Newfound Lake, Nippo Lake, Peaporridge Pond, Perkins Pond, Pleasant Lake, Silver Lake (Hollis), Silver Lake (Harrisville), Silver Lake (Madison), Silver Lake (Tilton), Squam Lakes, Lake Sunapee, Sunset Lake, Lake Waukewan, Lake Winona, Wentworth Lake and the towns of Alton, Amherst, Enfield, Hollis, Madison, Merrimack, Strafford and Wolfeboro.

SWAIN'S LAKE

1992 NON-TECHNICAL SUMMARY

Monitoring was undertaken at Swain's Lake by the volunteer monitors from July 12 through September 15, 1992. An in-depth analysis of the lake was undertaken by the FBG on August 20.

1) Water transparency at Swain's Lake was moderate, the sign of a moderately productive lake. The secchi disk was visible as far down as 4.7 meters (15.3 feet) and the transparency averages were 3.3 meters at site A and 3.7 meters at site B. This indicates the deepwater sites on the lake contain moderate levels of dissolved color and suspended matter such as algae and particulates. The Average water clarity at site A was similar to the 1991 average while the average water clarity at site B decreased to the lowest level since monitoring in the LLMP began in 1989 (see figure 13).

2) Chlorophyll *a* concentrations for the surface waters of Swain's Lake were moderate. Concentrations in the mixed layer of water averaged 4.6 milligrams per cubic meter (4.6 mg m^{-3} equivalent to about 4.6 parts chlorophyll per billion parts water) at site A and 3.6 mg m^{-3} at site B. However, the above chlorophyll *a* average for site A excludes a chlorophyll sample collected on August 2, as it extended into the thermocline and into an algal bloom occurring at 5 meters. The sample reached the concentration of 18.5 ppb which is considered indicative of more productive conditions. Samples collected in previous years (1989-1991) also demonstrate the presence of a mid-lake algal population occurring in Swain's Lake. We recommend collecting mid-lake chlorophyll samples in 1993 to determine the extent of this phenomenon, as higher mid-lake chlorophyll samples can be indicative of elevated nutrient levels.

3) Dissolved lakewater color levels for Swain's Lake were moderate in 1992, 29.5 ptu (platinate color units), and slightly higher than the average levels of 26 ptu in other program lakes. Small increases in water color from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality. However, increased color can lower water transparency, and hence, change the public perception of water quality. Large amounts of dissolved color may occur naturally but also occur during deforestation and development within the watershed. High color levels can actually mask the ability of the secchi disk transparency to predict chlorophyll levels.

4) Total phosphorus (nutrient) levels were low in the surface and bottom waters of both sampling stations when collected by the FBG on August 20. All phosphorous samples were in the range of 1.6 to 2.9 ppb which is well within the concentration of 15 ppb considered the boundary between less productive and more productive lakes. However, an error by the FBG (the samples were not preserved) likely resulted in a significant underestimate of phosphorous levels at the time of FBG sampling. The FBG will continue to focus on phosphorous levels in 1993 since the microscopic plant densities (measured as chlorophyll *a*) tend to indicate moderate to high nutrient levels, especially late in the summer.

5) The pH of the surface waters of the lake, measured by the FBG and volunteer monitors, remains within the optimum range for most aquatic organisms. The alkalinity of the lake, the lakes ability to buffer acid input, remains low, about 4 units lower than the average of 6.3 units for LLMP lakes. The alkalinity data indicate that Swain's Lake seems to have a low buffering capacity at this time to resist fluctuations in pH due to acid loadings.

6) The specific conductivity of the deep sites on Swain's Lake was low, ranging from 34.8 to 42.8 micro-Siemans. High conductivity values can indicate the presence of septic leachate or deicing road salt runoff.

7) Temperature profiles collected by the volunteer monitors disclosed the typical temperature stratification patterns for northern temperate lakes. With the depth of the upper mixed layer extending to 5.0 meters. Oxygen content of the bottom waters remained above 3 milligrams per liter (the minimum concentration required for successful reproduction and growth of most warmwater fish) to the lakebottom of site A, but only to about 6.0 meters at site B. High carbon dioxide and low dissolved oxygen levels in the bottom waters of site B suggest the accumulation of organic matter from algal and plant productivity as well as watershed runoff.

8) For all measurements considered and averaged for the season, Swain's Lake would be classified as a moderately productive, mesotrophic lake.

COMMENTS AND RECOMMENDATIONS

1) We recommend that each participating association, including the Swain's Lake Association, continue to develop its data base on lake water quality through continuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and eventually will enable more reliable predictions of water quality trends.

2) With the heavy snowfall this winter, we expect some substantial runoff this spring and recommend collecting nutrient (phosphorous) samples as well as taking alkalinity readings during this critical time. Both tributary and in lake samples are suggested.

3) An early August surface water (integrated) sample collected by the volunteer monitors extended into a mid-lake algal layer and reached the chlorophyll *a* concentration of 18.5 ppb. We recommend the collection of mid-lake chlorophyll samples late in the season (late July through early September) using the meyer bottle, to monitor this phenomenon as higher algal levels may be an indication of nutrient loading. We also suggest the collection of bottom water (hypolimnetic) phosphorous samples to assess the degree of internal nutrient loading.

With the initiation of metalimnetic (mid-lake) chlorophyll sampling, future sampling using the integrated sampler should be restricted to the surface waters (the layer of water in which the temperature changes less than 1^0C per meter of water) as samples extending deeper into the water column can bias the surface water samples.

INTRODUCTION

The New Hampshire Lakes Lay Monitoring Program

In this fifteenth year of operation, the NH Lakes Lay Monitoring Program has grown from a university class project on Chocorua Lake and pilot study on the Squam Lakes to a comprehensive state-wide program with over 500 volunteer monitors and more than 100 lakes participating. Originally developed to establish a data-base for determining long-term trends of lake water quality for science and management, the program has expanded by taking advantage of the many resources that citizen monitors can provide. The NH LLMP has an international reputation as a successful cooperative monitoring, education and research program. Current projects include: use of volunteer generated data for non-point pollution studies using high tech analysis system (Geographic Information Systems and Satellite Remote Sensing), intensive watershed monitoring for the development of lake nutrient budgets, and investigations of water quality and indicator organisms (food web analysis, fish condition, and stream invertebrates). The key ingredients responsible for the success of the program include innovative funding and cost reduction, assurance of credible data, practical sampling protocols and, most importantly, the interest and motivation of our volunteer monitors.

The 1992 sampling season was another exciting year for the New Hampshire Lakes Lay Monitoring Program. National recognition for the high quality of work by you, the volunteer monitors, continued with awards, requests for program information and invitations to speak at national conferences. We continue to be listed as a model citizen monitoring program on the Environmental Success Index of Renew America and on the Environmental Network Clearinghouse. To date, the approach and methods of the NH LLMP have been adopted by new or existing programs in fifteen states and nine countries !

Our Fish Condition Program intensive lake survey results have been tabulated, reports went to NH Fish & Game (our sponsor) and the results for individual lakes are forthcoming. Our fish study team is now focusing on the Newfound Lake fishery to determine the effects and results of alewife introduction.

In 1992 volunteers performed over 3000 measurements on lakes across the state as well as provided over 2000 samples that were analyzed in our UNH Freshwater Biology Group analytical lab. To date, data has been collected on over 100 lakes at over 440 sites by almost 600 volunteers who made over 10,492 lake sampling trips !

The General Scenario- 1992

Low snow pack (less water melting through the watershed at springtime) was again a factor in reduced spring runoff although we did see a handful of spring shower events early in the season. While mid and late summer conditions were more cloudy than typical, rainfall was again light. Thus, while not as dry as the summer of 1991, the 1992 summer season had below average precipitation. The general result of this was continued optimum water quality conditions for most lakes.

Lakes were clearer due to a combination of factors that could include lower dissolved color washed in from surrounding wetland areas, lower algae growth (measured as chlorophyll a) in the surface waters and lower suspended sediment levels. Dissolved color is not indicative of a water quality problems (although large increases in dissolved color sometime follow large land clearing operations) but in some of our more pristine program lakes it nevertheless has a large effect on water clarity changes.

With decreased nutrient runoff in the spring, and a lower water table situation translating into less of a chance of septic system failure, algae and some aquatic plant growth would be minimized.

As with color and nutrients the dryer season brought less suspended sediment load to many of our streams and lakes. If increased clarity was not the result of decreased color or chlorophyll levels then it was due to decreased suspended sediment by default. To find out how these water quality indicators inter-relate for a particular lake site compare the secchi disk, chlorophyll and color graphs enclosed in this report. Note whether changes in clarity (secchi disk depth) correspond to chlorophyll or color concentration changes or whether it is a combination of both. If neither seem to exhibit a consistent effect then sediment plays an important role in your lake's clarity.

A few NH LLMP lakes were actually worse off in 1992. These lakes included those more productive lakes in which a good deal of nutrients come internally from sediment release. Lakes with significant nutrient input from septic systems or shoreline fertilization and watering would also have a bad year under the 1992 conditions. Other lakes that fared worse this year were seepage lakes, shallow lakes that rely on groundwater (springs) in-flow and out-flow for replenishment and cleansing. With a low water table, these lakes became great "growth chambers" for algae.

Importance of Long-term Monitoring

A major goal of a monitoring program is to identify any short or long-term changes in the water quality of the lake. Of major concern is the detection of cultural eutrophication: increases in the productivity of the lake, the amount of algae and plant growth, due to the addition of nutrients from human activities. Changes in the natural buffering capacity of the lakes in the program is also a topic of great concern, as New Hampshire receives large amounts of acid precipitation, yet most of our lakes contain little mineral content to neutralize this type of pollution.

For almost a decade and a half, data collected weekly from lakes participating in the **New Hampshire Lakes Lay Monitoring Program** have indicated there is quite a variation in water quality indicators through the open water season on the majority of lakes. Short-term differences may be due to variations in weather, lake use, or other chance events. Monthly sampling of a lake during a single summer provides some useful information, but there is a greater chance that important short-term events such as algal blooms or the lake response to storm run-off will be missed. These short-term fluctuations may be unrelated to the actual long-term trend of a lake or they may be indicative of the changing status or "health" of a lake.

To determine if a change in water quality is occurring, a lake must be sampled on a frequent basis over a substantial amount of time. A poorly designed sampling program may even mislead the investigator away from the actual trend: Consider the hypothetical lake in Figure 1. Sampling only once a year during August from 1982 to 1986 would produce a plot (Fig. 2) suggesting a decrease in eutrophication. The actual long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling additional times a year for a ten year period (Fig. 1). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term trends ("signal"). To that end, the lake must establish a long-term data base.

The number of seasons it takes to distinguish between the noise and the signal is not the same for each lake. Evaluation and interpretation of a long-term data base will indicate that the water quality of the lake has worsened, improved, or remained the same. In addition, different areas of a lake may show a different response. As more data is collected, prediction of current and future trends can be made. No matter what the outcome, this information is essential for the intelligent management of the lake.

There are also short-term uses for lay monitoring data. The examination of different stations in a lake can disclose the location of specific problems and corrective action can be initiated to handle the situation before it becomes more serious. On a lighter note, some associations post their weekly data for use in determining the best depths for finding fish!

It takes a considerable amount of effort as well as a deep concern for one's lake to be a lay monitor in the NH Lakes Lay Monitoring Program. Many times a monitor has to brave inclement weather or heavy boat traffic to collect samples. Sometimes it even may seem that one week's data is just the same as the next. Yet every sampling provides important information on the variability of the lake.

We are pleased with the interest and commitment of our lay monitors and are proud that their work is what makes the **NH LLMP** the most extensive, and we believe, the best volunteer program of its kind.

Purpose and Scope of This Study

This was the fourth year that monitoring of Swain's Lake was undertaken by the Freshwater Biology Group and the Swain's Lake Association. The program of sampling was designed to continue adding data to the long-term data base established. Sampling emphasis was placed on two open water deep stations. A more in-depth study of the deep lake sites was undertaken by the FBG on August 20.

The primary purpose of this report is to discuss results of the 1992 monitoring with emphasis on current conditions of Swain's Lake including the extent of eutrophication and the lake's susceptibility to increasing acid precipitation. This information is part of a large data base of historical and more recent data compiled and entered onto computer files for New Hampshire lakes that include New Hampshire Fish and Game surveys of the 1930's, the surveys by the New Hampshire Water Supply and Pollution Control Commission and the FBG surveys. Care must be taken when comparing current results with early studies. Many complications arise due to methodological differences of the various testing facilities and technological improvements in testing.

DISCUSSION OF LAKE MONITORING MEASUREMENTS

The section below details the important concepts involved for the various testing procedures used in the New Hampshire Lakes Lay Monitoring Program. Where appropriate, summary statistics of 1992 results from all participating lakes are included. Certain tests or sampling performed at the time of the optional Freshwater Biology Group field trip are indicated by an asterisk (*).

Thermal Stratification in the Deep Water Sites

Lakes in New Hampshire display distinct patterns of temperature stratification, that develop as the summer months progress, where a layer of warmer water (the **epilimnion**) overlies a deeper layer of cold water (**hypolimnion**). The layer that separates the two regions characterized by a sharp drop in temperature with depth is called the **thermocline** or **metalimnion**. Some shallow lakes may be continually mixed by wind action and will never stratify. Other lakes may only contain a developed epilimnion and metalimnion.

Swain's Lake is shallow and became only partially stratified when the weather was calm.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it.

In the shallow areas of many lakes, the secchi disk will hit bottom before it is able to disappear from view (what is referred to as a "Bottom Out" condition). Thus, Secchi disk measurements are generally taken over the deepest sites of a lake. Transparency values of greater than 4 meters are typical of clear, less productive lakes. Values less than 2.5

meters are generally an indication of a very productive lake. In 1992 the average transparency for lakes participating in the NH LLMP was 5.6 meters with a range of 1.8 to 12.5 meters.

Secchi disk readings collected at Swain's Lake in 1992 were moderate and averaged 3.3 meters (range: 2.5 to 4.0 meters) at site A and 3.7 meters (range: 3.0 to 4.7 meters) at site B. The lowest secchi disk reading of 2.5 meters, collected on August 2 at site A, corresponded to an algal bloom occurring at that time (see figures 4 and 5).

Chlorophyll a

The chlorophyll a concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Characteristics include accumulated organic matter in the lake basin and lower dissolved oxygen in the bottom waters. Summer chlorophyll a concentrations average above 7 mg m^{-3} (7 milligrams per cubic meter; 7 parts per billion). **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll a concentrations are generally less than 3 mg m^{-3}. These lakes generally have cleaner bottoms and high dissolved oxygen levels throughout. **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll a generally between 3 mg m^{-3} and 7 mg m^{-3}. In 1992 the average chlorophyll for lakes participating in the NH LLMP was 2.8 mg m^{-3} with a range of 0.4 to 18.5 mg m^{-3}.

Surface water chlorophyll levels in Swain's Lake were moderate in 1992 and averaged 4.6 mg m^{-3} (range: 2.4 to 7.8 mg m^{-3}) at site A and averaged 3.6 mg m^{-3} (range: 2.6 to 4.8 mg m^{-3}) at site B. The 1992 seasonal average chlorophyll level of site A was higher than the 1991 average level, while the seasonal average chlorophyll level of site B was similar to the 1991 average level.

Testing is sometimes done to check for **metalimnetic algal populations**, algae that layer out at the thermocline and generally go undetected if only epilimnetic (point or integrated) sampling is undertaken. Chlorophyll concentrations of a water sample collected in the thermocline is compared to the integrated epilimnetic sample. Greater chlorophyll levels of the point sample, in conjunction with microscopic examination of the samples (see Phytoplankton section below), confirm the presence of such a population of algae. These populations should be monitored as they may be an indication of increased nutrient loading into the lake.

A sample collected by the volunteer monitors on August 2 at site A extended into the thermocline and indicates the presence of such an algal population. The chlorophyll concentration reached 18.5 ppb at that time, which is typical of more productive, eutrophic conditions. Further monitoring should include metalimnetic chlorophyll samples late in the season to determine the extent of this phenomenon.

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from **humic substances**, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters. Increases in dissolved watercolor can be an indication of increased development within the watershed as many land clearing activities (construction, deforestation, and the resulting increased run-off) add additional organic material to lakes. Natural fluctuations of dissolved color occur when storm events increase drainage from wetlands areas within the watershed. As suspended sediment is a difficult and expensive test to undertake, both dissolved color and chlorophyll information is important when interpreting the secchi disk transparency.

Dissolved color is measured on a comparative scale that uses standard chloroplatinate dyes and is designated as a color unit or ptu. Lakes with color below 10 ptu are very clear, 10 to 20 ptu are slightly colored, 20 to 40 ptu are lightly tea colored, 40 to 80 ptu are tea colored and greater than 80 ptu indicates highly colored waters. Generally the majority of New Hampshire lakes have color between 20 to 30 ptu.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources arise primarily through human related activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton. As little as 15 parts per billion of phosphorus in a lake can cause an algal bloom.

Generally, in the more pristine lakes, phosphorus values are higher after spring melt when the lake receives the majority of runoff from its surrounding watershed. The nutrient is used by the algae and plants which in turn die and sink to the lake bottom causing phosphorus to decrease as the summer progresses. Lakes with nutrient loading from human activities and sources (Agriculture, Sediment Erosion, Septic Systems, etc) will show greater concentrations of nutrients as the summer progresses or after major storm events. Circulation of nutrients from the bottom waters of more productive lakes in late fall can result in algal blooms.

Phosphorous samples collected by the FBG on August 20 were low and ranged from 1.6 to 2.9 ppb. However, the phosphorous samples were not preserved prior to freezing which resulted in artificially low levels.

pH *

The pH is a way of expressing the acidic level of lake water, and is generally measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (ie: changes in 1 pH unit reflect a ten times difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

PH samples collected by the FBG on August 20 ranged from 6.3 to 6.5 units which is within the range of tolerance for most aquatic organisms.

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock and soils of lake watersheds.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada by Schindler, gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton.

The analysis of alkalinity employed by the **Freshwater Biology Group** includes use of a dilute titrant allowing an order of magnitude greater sensitivity and precision than the standard method. Two endpoints are recorded during each analysis. The first endpoint (grey color of dye; pH endpoint of 5.1) approximates low level alkalinity values, while the second endpoint (pink dye color; pH endpoint of 4.6) approximates the alkalinity values recorded historically, such as NH Fish and Game data, with the methyl-orange endpoint method.

The average alkalinity of lakes throughout New Hampshire is low, approximately 9 mg per liter (calcium carbonate alkalinity), while the average alkalinity of the lakes studied by the **Freshwater Biology Group** in the NH LLMP is approximately 6.3 mg per liter. When alkalinity falls below 2 mg per liter the pH of waters can greatly fluctuate. Alkalinity levels are most critical in the spring when acid loadings from snowmelt and run-off are high, and many aquatic species are in their early, and most susceptible, stages of their life cycle.

Alkalinity levels in Swain's Lake are very low and about 4 units lower than other **LLMP** lakes.

Specific Conductivity *

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and deicing salt runoff from highways can cause high conductivity values. Fertilizers and other pollutants can also increase the conductivity of the water. Conductivity is measured in micro**mhos** (the opposite of the measurement of resistance **ohms**) per centimeter, more commonly referred to as micro-Siemans.

Conductivity was low in Swain's Lake, ranging from 34.8 to 40.2 micro-Siemans at site A and from 38.5 to 42.8 micro-Siemans at site B.

Dissolved Oxygen and Free Carbon Dioxide *

Oxygen is an essential component for the survival of aquatic life. Submergent plants and algae take in free carbon dioxide and create oxygen through **photosynthesis** by day. **Respiration** by both animals and plants uses up oxygen continually and creates **carbon dioxide.** Dissolved oxygen profiles determine the extent of declining oxygen concentrations in the lower waters. High carbon dioxide values are indicative of low oxygen conditions and accumulating organic matter. For both gases, as the temperature of the water decreases, more gas can be dissolved in the water.

The typical pattern of clear, unproductive lakes is a slight decline in hypolimnetic oxygen as the summer progresses. Oxygen in the lower waters is important for maintaining a fit, reproducing, cold water fishery. Trout and salmon generally require oxygen concentrations above 5 mg per liter (parts per million) in the cool deep waters. On the other hand, carp and catfish can survive very low oxygen conditions. Oxygen above the lake bottom is important in limiting the release of nutrients from the sediments and minimizing the collection of undecomposed organic matter.

Bacteria, fungi and other **decomposers** in the bottom waters break down organic matter originating from the watershed or generated by the lake. This process uses up oxygen and produces carbon dioxide. In lakes where organic matter accumulation is high, oxygen depletion can occur. In highly stratified eutrophic lakes the entire hypolimnion can remain unoxygenated or **anaerobic** until fall mixing occurs.

The oxygen peaks occurring at surface and mid-lake depths during the day are quite common in many lakes. These characteristic **heterograde oxygen curves** are the result of the large amounts of oxygen, the by-product of photosynthesis, collecting in regions of high algal concentrations. If the peak occurs in the thermocline of the lake, metalimnetic algal populations (discussed above) may be present.

The oxygen content of the bottom waters remained high at site A but dropped below the level of 3 ppb, thought to be the minimum concentration required for the successful growth and reproduction of most warmwater fish, at site B. Low oxygen and high carbon dioxide levels in the bottom waters of site B suggest the accumulation of organic matter from algal and plant productivity as well as watershed runoff.

Underwater Light *

Underwater light available to photosynthetic organisms is measured with an **underwater photometer** which is much like the light meter of a camera (only waterproofed !). The **photic zone** of a lake is the volume of water capable of supporting photosynthesis. It is generally considered to be delineated by the water's surface and the level where light is reduced, by the absorption and scattering properties of the lake water, to one percent of the surface intensity. The one percent depth is sometimes termed the **compensation depth**. Knowledge of light penetration is important when considering lake productivity and in studies of submerged vegetation. Discontinuity (abrupt changes in the slope) of the profiles could be due to metalimnetic layering of algae or other particulates (discussed above). The underwater photometer allows the investigator to measure light at depths below the Secchi disk depth to supplement the transparency information.

Light profiles collected by the FBG on August 20 indicate the photic zone of Swain's Lake extended to about 5.3 meters at site A and to about 6.3 meters at site B. That is to say, plants can grow down to about 5.3 meters at site A and to about 6.3 meters at site B.

Indicator Bacteria *

Coliform bacteria in water indicate the possibility of fecal contamination. Although they are usually considered harmless to humans, they are much easier to test for than harmful pathogenic enteric bacteria (**Salmonella**, **Shigella** etc.) and viruses that may be present in fecal material. **Total coliform** includes all coliform bacteria which arise from the gut of animals or from vegetative materials. **Fecal coliform** are those specific organisms that inhabit the gut of warm blooded animals. Another indicator organism **Fecal streptococcus** (sometimes referred to as **enterococcus**) also can be monitored. The ratio of fecal coliform to fecal strep may be useful in suggesting the type of animal source responsible for the contamination. Desirable levels for a Class A water body is less than 50 total coliform organisms per 100 milliliters. If the coliform level rises above 150 organisms per 100ml swimming should be prohibited.

Ducks and geese are often a common cause of high concentrations of coliform at specific lake sites. While waterfowl are important components to the natural and aesthetic qualities of lakes that we all enjoy, it is poor management practice to encourage these birds by feeding them. The lake and surrounding area provides enough healthy and natural food for the birds and feeding them stale bread or crackers does nothing more than import additional nutrients into the lake and allows for increased plant growth. As birds also are a host to the parasite that causes "swimmers itch" waterfowl roosting areas offer a greater chance for infestation to occur. Thus while leaving offerings for our feathered friends is enticing, the results can prove to be detrimental to the lake system and to human health.

Phytoplankton *

The planktonic community includes microbial organisms that represent diverse life forms, containing photosynthetic as well as non-photosynthetic types, and including bacteria, algae, crustaceans and insect larvae (the zooplankton are discussed below in a separate section). Because planktonic algae or "phytoplankton" tend to undergo rapid seasonal cycles on a time scale of days and weeks, the levels of populations found should be considered to be most representative of the time of collection and not necessarily of other times during the ice-free season, especially the early spring and late fall periods.

The composition and concentration of phytoplankton can be indicative of the trophic status of a lake. Seasonal patterns do occur and must be considered. For example **diatoms**, tend to be most abundant in April-June and October-November, in the surface or epilimnetic layers of New Hampshire lakes. As the summer progresses, the dominant types might shift to **green algae** or **golden algae**. By late season **Blue-green bacteria** generally dominate. In nutrient rich lakes, nuisance green algae and/or bluegreen bacteria might dominate continually. After fall mixing diatoms might again be found to bloom.

Phytoplankton samples collected in the surface waters of the lake were low to moderate in density and were dominated by the blue-green bacteria, *Lyngbya* at both deep sampling stations. The composition of algae in the surface waters is indicative of a moderately productive lake. An algal sample collected at mid-lake depth was also dominated by the blue-green bacteria, *Lyngbya*, which composed 97% of the algal community! The phytoplankton density of the mid-lake algal population reached 11923.8 organisms per milliliter, of which 11578.7 organisms were the blue-green bacteria, *Lyngbya*. The low diversity and extremely high concentration of *Lyngbya* is indicative of a moderately to highly productive lake and suggests an accumulation of nutrients in the bottom waters.

Zooplankton *

There are three groups of zooplankton that are generally prevalent in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints usually make it necessary to sample only the larger zooplankton (macrozooplankton; larger than 80 or 150 microns; 1 million microns make up a meter). Thus, zooplankton analysis is generally restricted only to the larger crustaceans. Crustacean zooplankton are very sensitive to pollutants and are commonly used to indicate the presence of toxic substances in water. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods.**

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake.

As discussed above for phytoplankton, zooplankton undergo seasonal population cycles and the results discussed below are most representative of the collection dates and not necessarily of other times during the ice-free season, especially during the early spring and late fall.

The macrozooplankton density was high at both deep sampling stations, 42.1 and 17.9 animals per liter, at sites A and B respectively. The macrozooplankton community of Swain's Lake was dominated by the Cyclopoid and Calanoid copepods at both deep sampling stations. A moderate density of the cladoceran, *Diaphanosoma*, was present at the western sampling station (site A) which is often indicative of more productive systems, as they feed on bacteria (naturally occurring heterotrophic bacteria, not necessarily that of septic systems). Microscopic examination of the phytoplankton samples confirmed the presence of high concentrations of bacteria at site A, as was expected. The macrozooplankton composition and density in Swain's Lake are indicative of a moderately productive system.

Fish Condition

As with the plankton discussed above, the health of the fish species of a lake will be indicative of the overall water quality. Condition is determined by comparing the length of the fish to its weight. As would be expected, the heavier the fish for its length, the better its condition will be. By also examining a scale collected from the fish under a microscope, the approximate age and growth history can also be determined.

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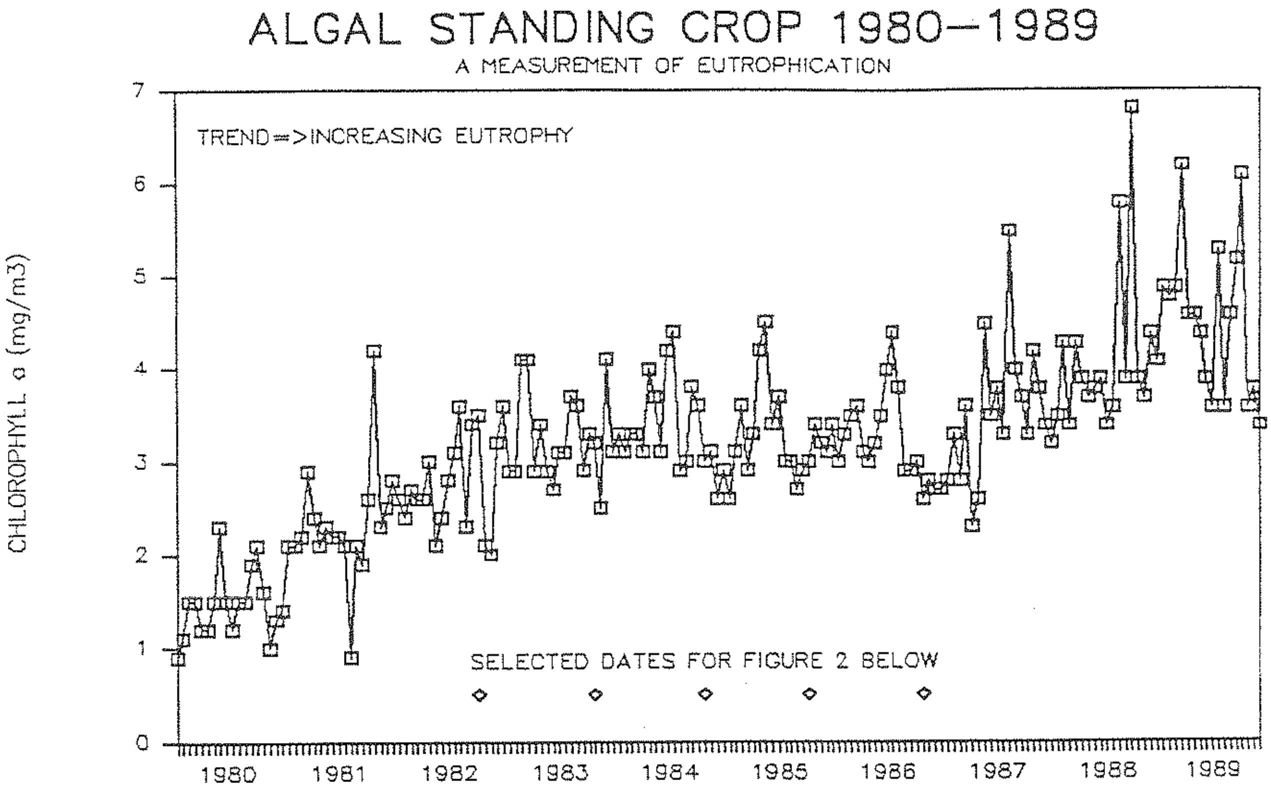
REPORT FIGURES



.Figure 1. The upper graph depicts weekly chlorophyll concentrations of a model lake measured weekly during ice-free conditions. The long-term trend is that of increased eutrophication (lake has become "greener"). Diamonds below the curve represent late summer (August) dates the data set was subsampled to create Figure 2.

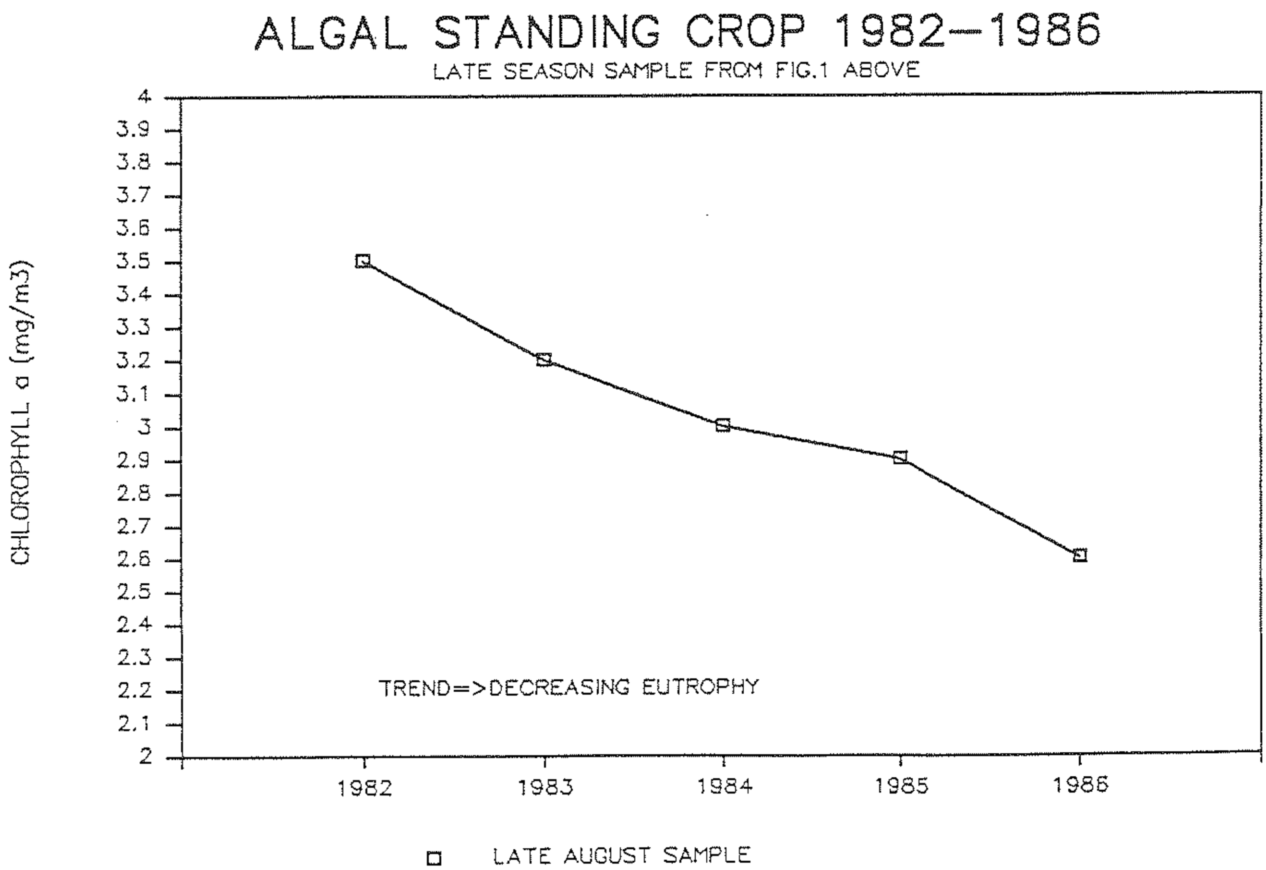


Figure 2. The lower graph depicts late summer chlorophyll data of the model lake in Figure 1. Note how limited sampling over a five year period suggests a much different trend, that of decreasing eutrophy. Thus, limited sampling can mislead the investigator of long-term trends.

Figure 3. Location of 1992 deep lake sampling stations (Site A and Site B) for Swain's Lake, New Hampshire.

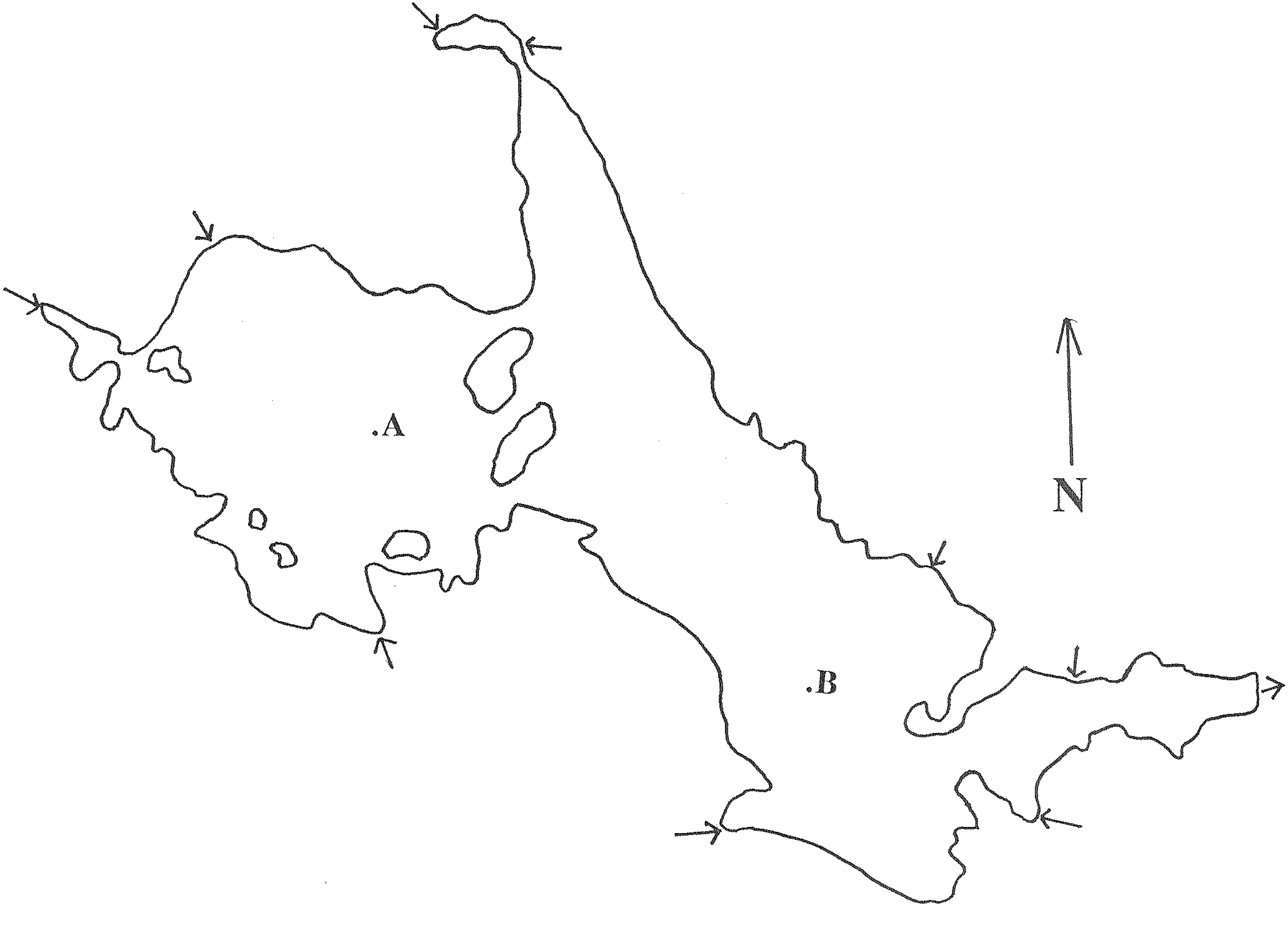
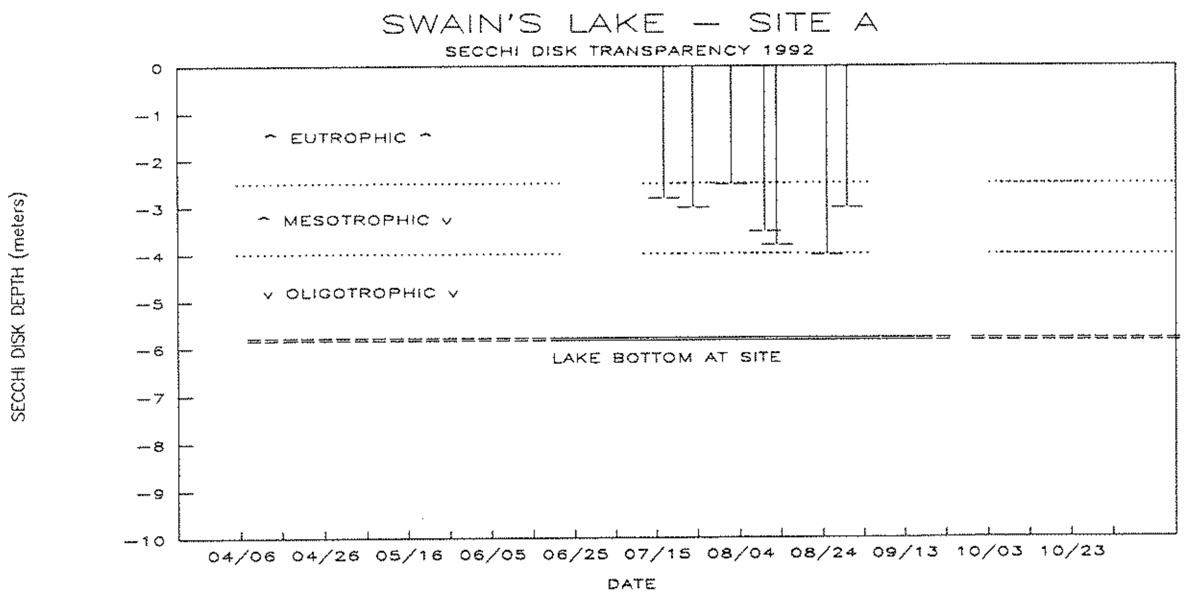
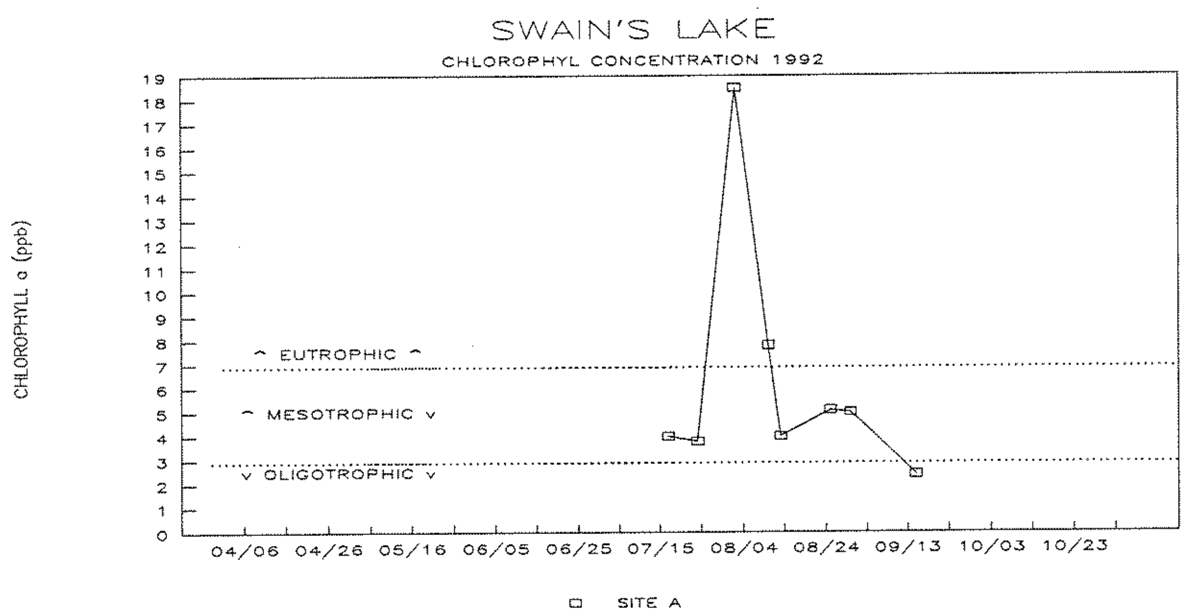

.A
.B
N

Figure 4. Seasonal trends for Secchi Disk Depth (water transparency) 1992, Site A. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 5. Swain's Lake 1992. Seasonal trends for chlorophyll *a* concentration of lay monitor Site A. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*.

Figure 6. Swain's Lake 1992. Seasonal trends for dissolved color concentration of lay monitor Site A. Color expressed as platinum-cobalt units (ptu).


SWAIN'S LAKE — SITE A
SECCHI DISK TRANSPARENCY 1992
SECCHI DISK DEPTH (meters)
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SWAIN'S LAKE
CHLOROPHYL CONCENTRATION 1992
CHLOROPHYLL a (ppb)
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE A

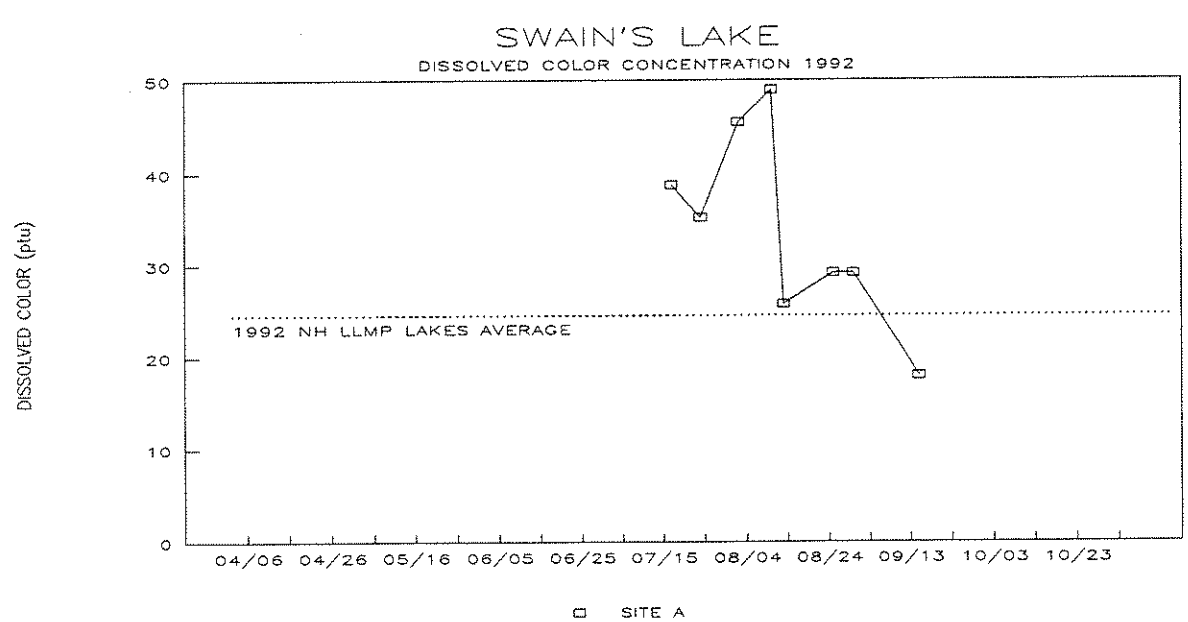
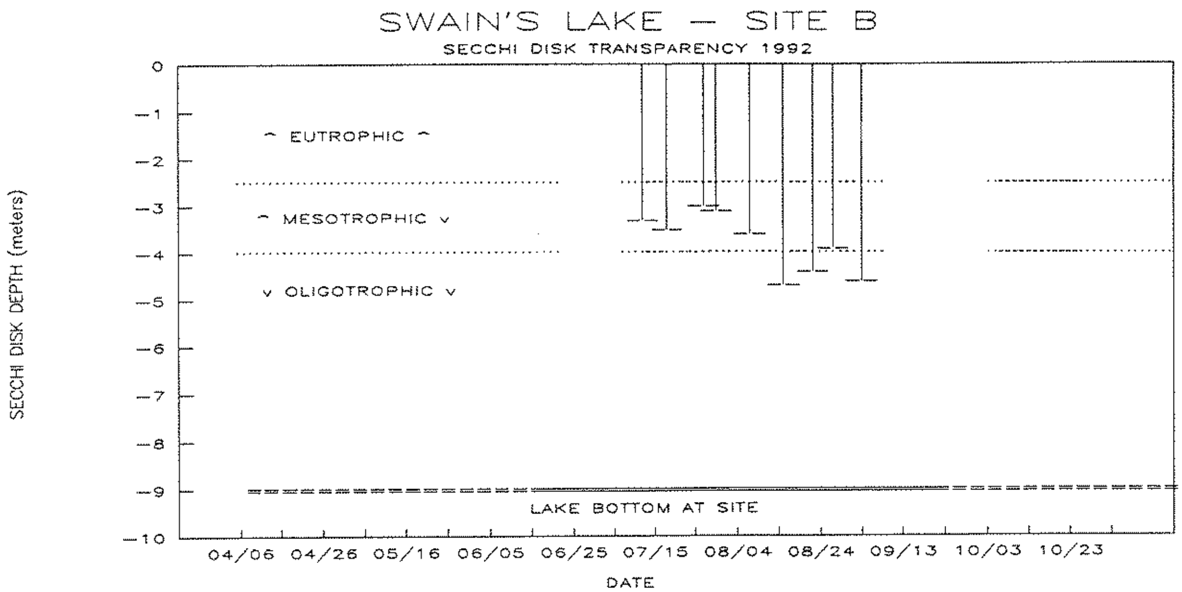
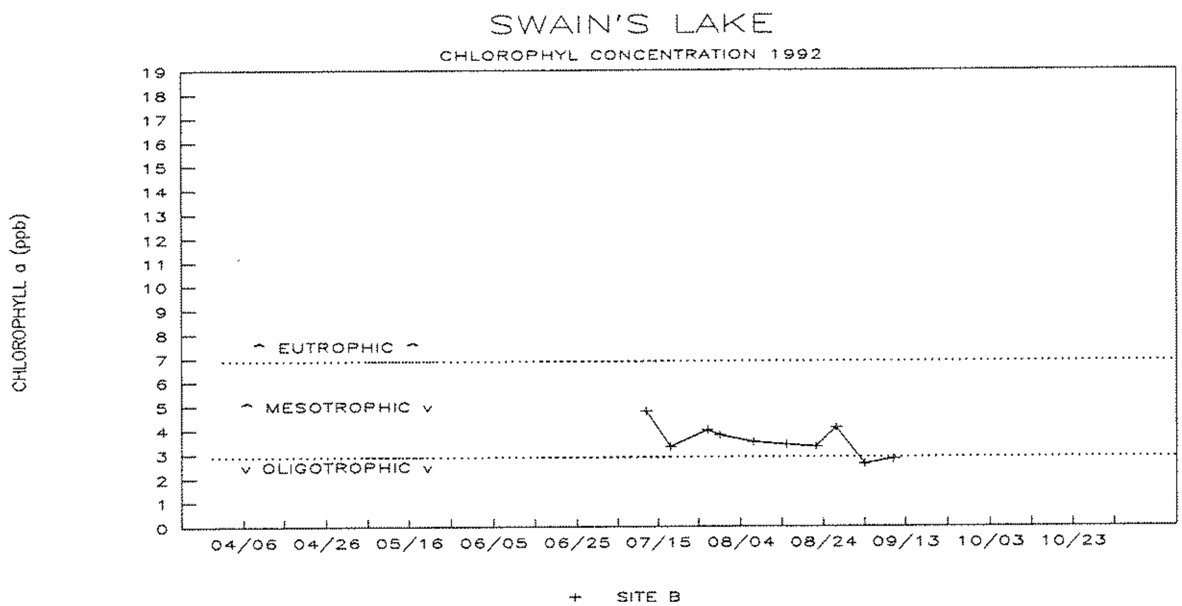

SWAIN'S LAKE
DISSOLVED COLOR CONCENTRATION 1992
DISSOLVED COLOR (ptu)
50
40
30
20
10
0
1992 NH LLMP LAKES AVERAGE
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE A

Figure 7. Seasonal trends for Secchi Disk Depth (water transparency) 1992, Site B. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

Figure 8. Swain's Lake 1992. Seasonal trends for chlorophyll *a* concentration of lay monitor site B. Chlorophyll *a* concentrations in parts per billion (ppb) of chlorophyll *a*.

Figure 9. Swain's Lake 1992. Seasonal trends for dissolved color concentration of lay monitor site B. Color expressed as platinum-cobalt units (ptu).


SWAIN'S LAKE — SITE B
SECCHI DISK TRANSPARENCY 1992
SECCHI DISK DEPTH (meters)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
LAKE BOTTOM AT SITE
0
-1
-2
-3
-4
-5
-6
-7
-8
-9
-10
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
DATE


SWAIN'S LAKE
CHLOROPHYL CONCENTRATION 1992
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ SITE B

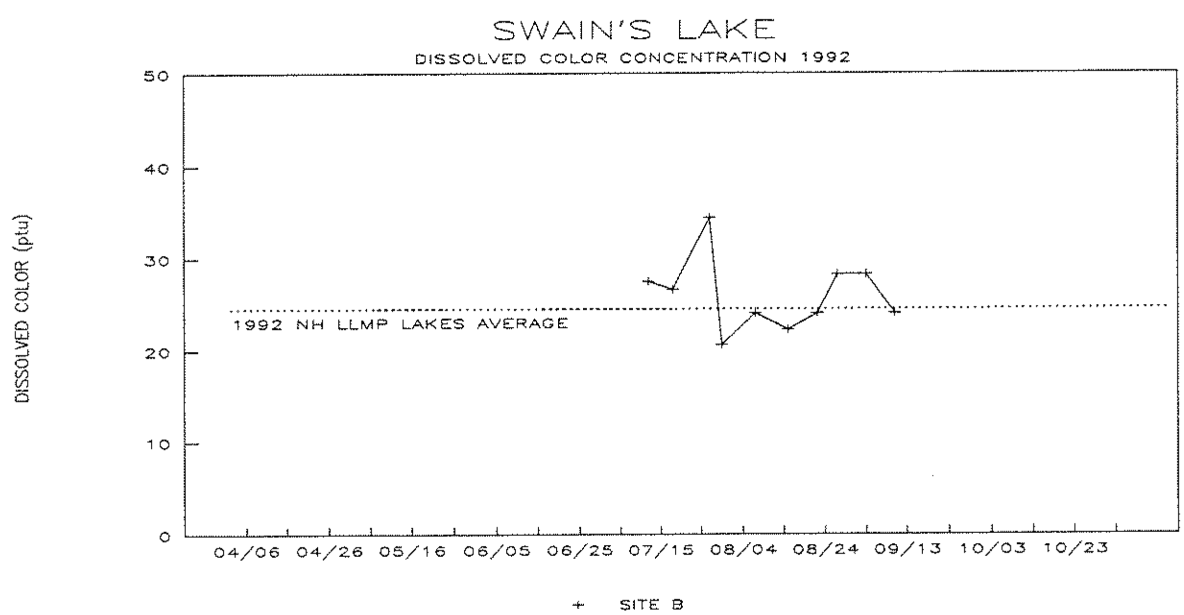
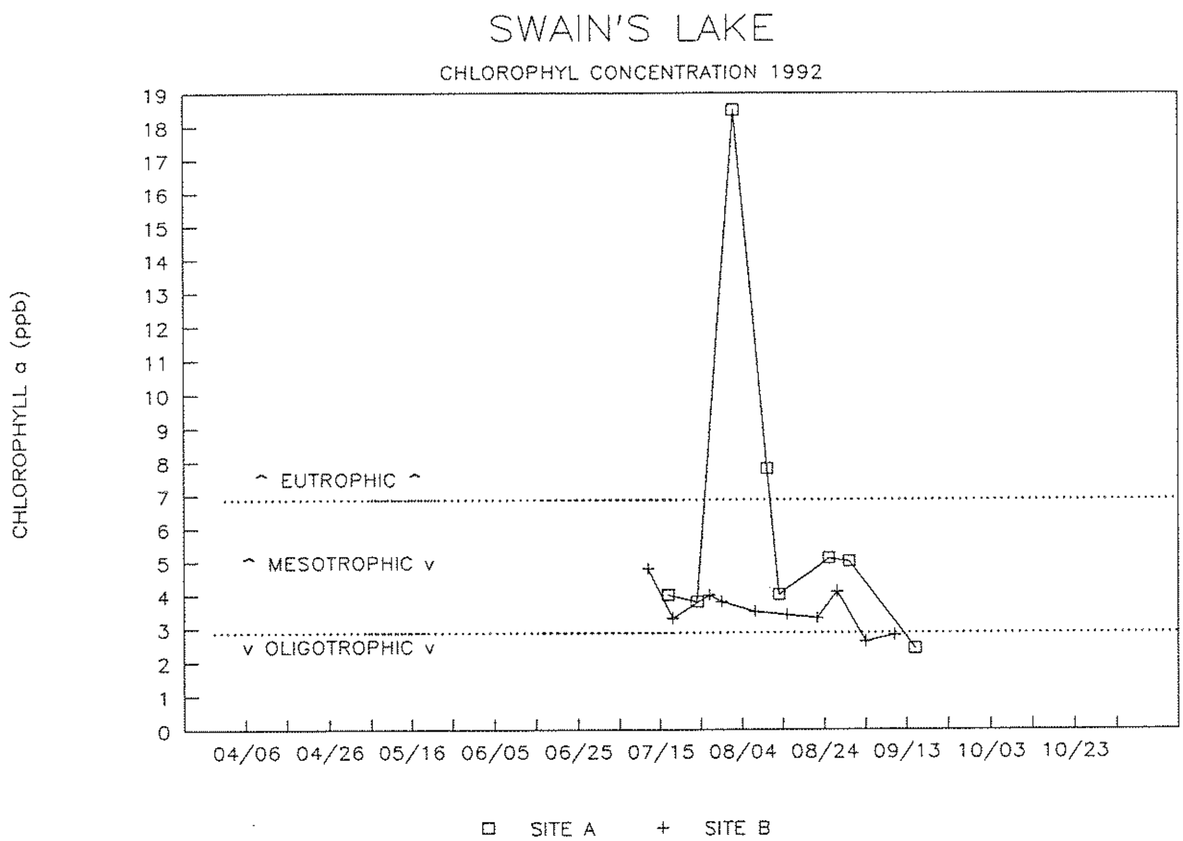

SWAIN'S LAKE
DISSOLVED COLOR CONCENTRATION 1992
DISSOLVED COLOR (ptu)
1992 NH LLMP LAKES AVERAGE
50 40 30 20 10 0
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
+ SITE B

Figure 10. Swain's Lake 1992. Seasonal trends for chlorophyll *a* concentration of lay monitor sites A (squares) and B (crosses). Chlorophyll *a* concentration in parts per billion (ppb) of chlorophyll *a*.

Figure 11. Swain's Lake 1992. Seasonal trends for dissolved color concentrations of lay monitor sites A (squares) and B (crosses). Color expressed as platinum-cobalt units (ptu).


SWAIN'S LAKE
CHLOROPHYL CONCENTRATION 1992
CHLOROPHYLL a (ppb)
^ EUTROPHIC ^
^ MESOTROPHIC v
v OLIGOTROPHIC v
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE A
SITE B

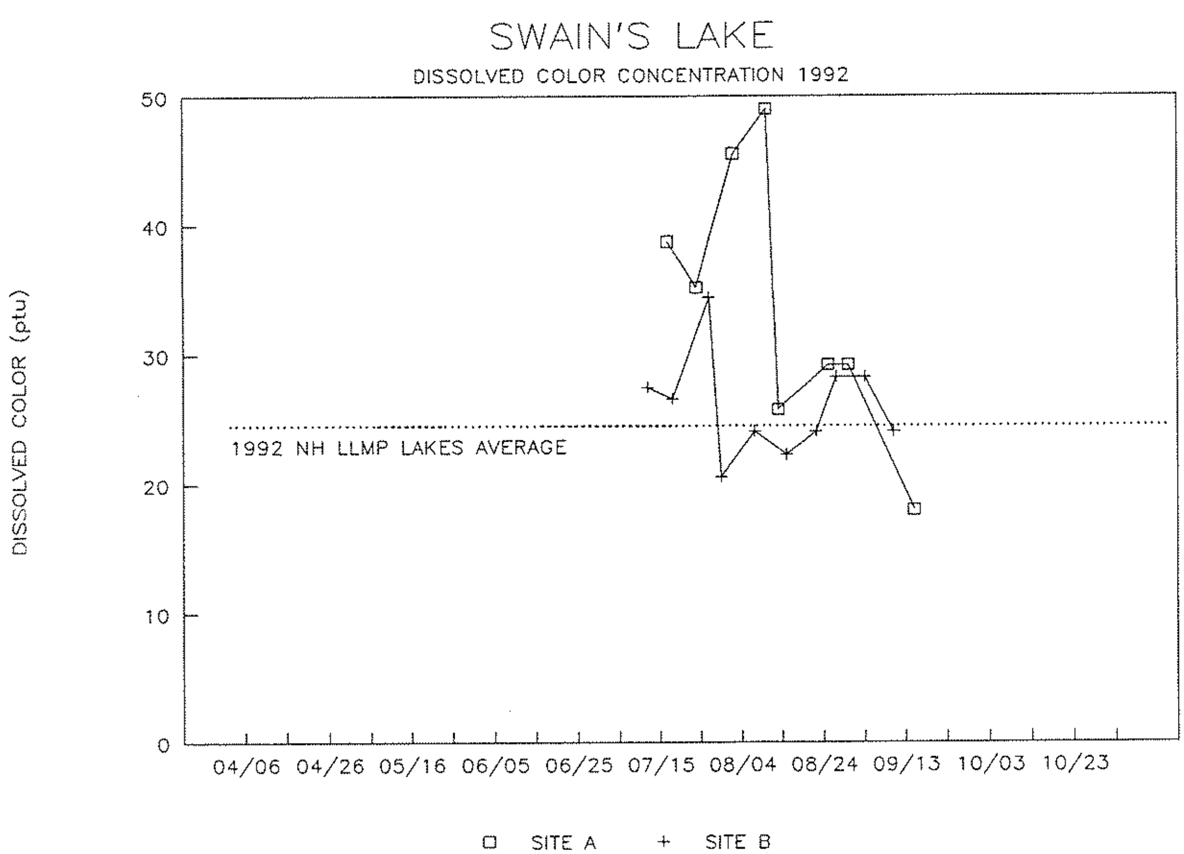
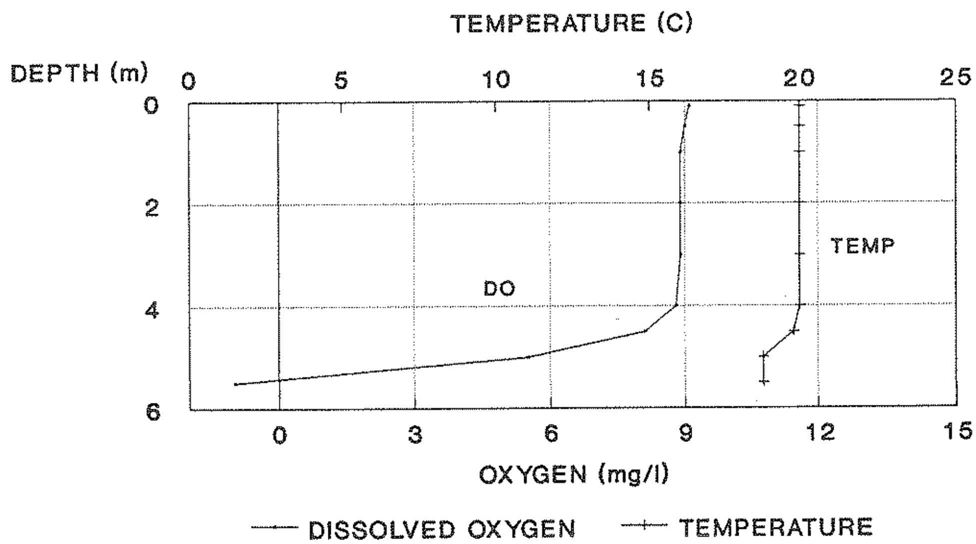

SWAIN'S LAKE
DISSOLVED COLOR CONCENTRATION 1992
DISSOLVED COLOR (ptu)
1992 NH LLMP LAKES AVERAGE
0 10 20 30 40 50
04/06 04/26 05/16 06/05 06/25 07/15 08/04 08/24 09/13 10/03 10/23
SITE A
SITE B

Figure 12. Profiles of temperature (TEMP) and dissolved oxygen (DO) taken on August 20, 1992 in Swain's Lake (A) Site A and (B) Site B. Units of measurement are as indicated. Dissolved oxygen and temperature were measured at one-half meter intervals.

TEMPERATURE - OXYGEN PROFILE
SWAINS - SITE A
AUGUST 20, 1992



TEMPERATURE - OXYGEN PROFILE
SWAINS - SITE B
AUGUST 20, 1992

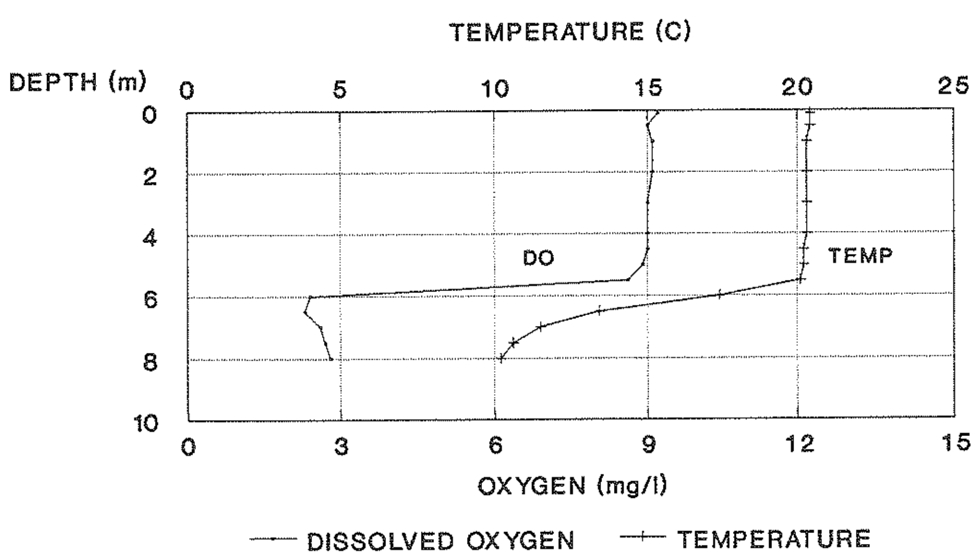
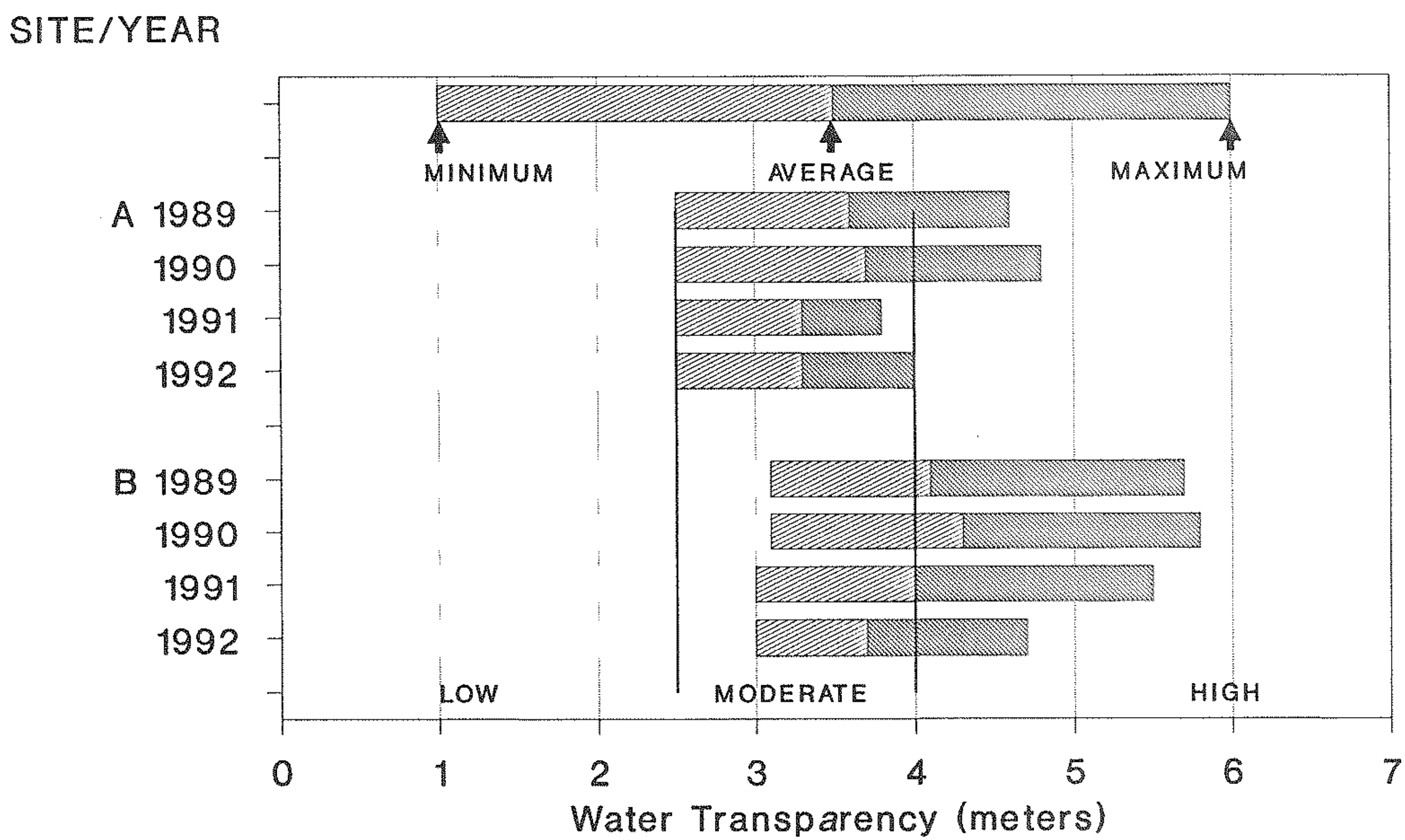


Figure 13. Comparison of Swain's Lake 1992 lay monitor Secchi Disk Transparency data with previous yearly data. The patterns of the bars display the minimum, mean and maximum values for each year sampled while the length of the bar represents the total range of values. The higher the secchi disk value, the clearer the pond. Secchi disk readings are taken to the nearest tenth (0.1) of a meter.

SWAIN'S LAKE

YEARLY COMPARISONS OF SECCHI DISK DATA
LAY MONITOR DATA

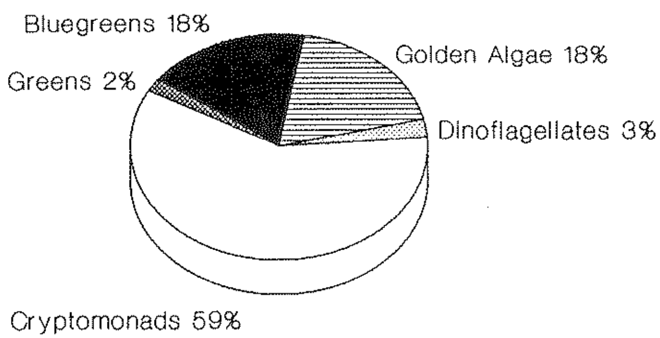


The higher number = clearer water

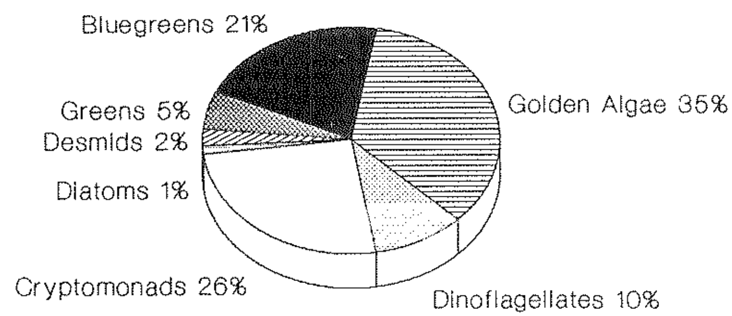
Figure 14. Pie diagrams of Phytoplankton Abundance by algal class. Phytoplankton samples collected on August 20 at the deep sampling stations A and B.

SWAIN'S LAKE
20 AUGUST 1992

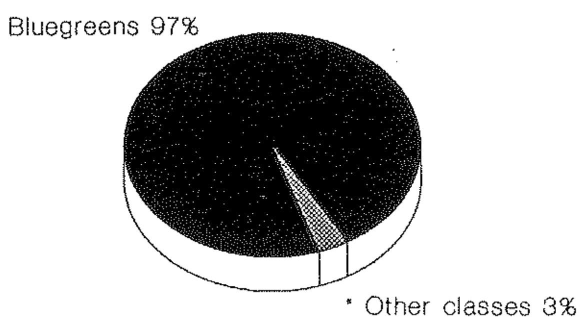
SITE A
DEPTH 0-4.5 meters



SITE B
DEPTH 0-5.5 meters



SITE B
DEPTH 7.0 meters



PHYTOPLANKTON ABUNDANCE % BY ALGAL CLASS

Swain's Lake Data on file as of 12/29/1992

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Swain's Lake, NH
-- subset of trophic indicators, all sites, 1992

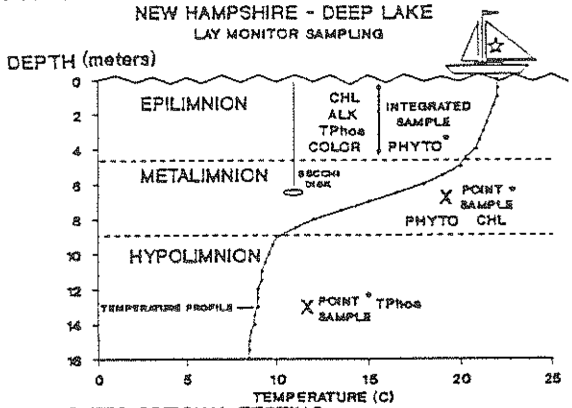
1992 SUMMARY

Average transparency:	3.5	(1992:	18	values;	2.5	-	4.7	range)
Average chlorophyll:	4.8	(1992:	18	values;	2.4	-	18.5	range)
Average alk (gray):	2.0	(1992:	18	values;	1.0	-	3.1	range)
Average alk (pink):	3.1	(1992:	18	values;	2.0	-	4.2	range)
Average color, 440:	29.5	(1992:	18	values;	18.0	-	49.0	range)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
A	07/17/1992	2.8	4.0	---	1.8	3.1	38.7
A	07/24/1992	3.0	3.8	---	1.0	2.0	35.2
A	08/02/1992	2.5	18.5	---	3.1	4.2	45.5
A	08/10/1992	3.5	7.8	---	2.0	3.3	49.0
A	08/13/1992	3.8	4.0	---	1.2	2.2	25.8
A	08/25/1992	4.0	5.1	---	2.2	3.2	29.2
A	08/30/1992	3.0	5.0	---	2.0	3.5	29.2
A	09/15/1992	4.0	2.4	---	2.2	3.2	18.0
B	07/12/1992	3.3	4.8	---	2.1	3.2	27.5
B	07/18/1992	3.5	3.3	---	1.5	2.8	26.6
B	07/27/1992	3.0	4.0	---	2.4	3.4	34.4
B	07/30/1992	3.1	3.8	---	1.7	3.4	20.6
B	08/07/1992	3.6	3.5	---	1.6	2.6	24.1
B	08/15/1992	4.7	3.4	---	2.2	3.3	22.3
B	08/22/1992	4.4	3.3	---	2.1	2.8	24.1
B	08/27/1992	3.9	4.1	---	2.3	3.2	28.3
B	09/03/1992	4.6	2.6	---	2.0	3.1	28.3
B	09/10/1992	3.0	2.8	---	2.2	3.4	24.1

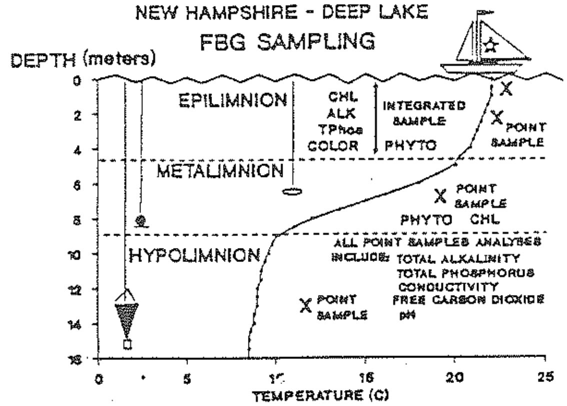
<< End of 1992 listing, 18 records >>

TYPICAL TEMPERATURE CONDITIONS : SUMMER
NEW HAMPSHIRE - DEEP LAKE
LAY MONITOR SAMPLING

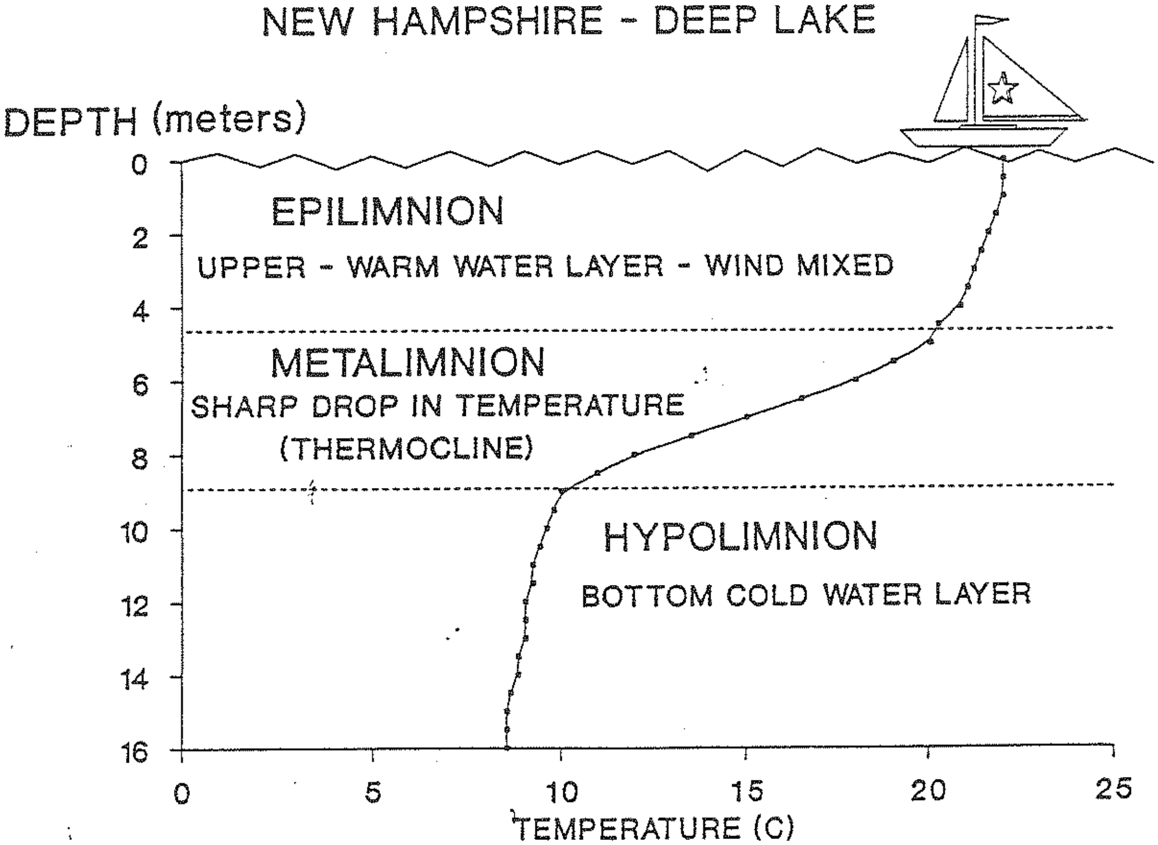


* - INDICATES OPTIONAL TESTING

TYPICAL TEMPERATURE CONDITIONS : SUMMER
NEW HAMPSHIRE - DEEP LAKE
FBG SAMPLING



TYPICAL TEMPERATURE CONDITIONS : SUMMER
NEW HAMPSHIRE - DEEP LAKE



APPENDIX C

GLOSSARY OF LIMNOLOGICAL TERMS

Aerobe- Organisms requiring oxygen for life. All animals, most algae and some bacteria require oxygen for respiration.

Algae- See phytoplankton.

Alkalinity- Total concentration of bicarbonate and hydroxide ions (in most lakes).

Anaerobe- Organisms not requiring oxygen for life. Some algae and many bacteria are able to respire or ferment without using oxygen.

Anoxic- A system lacking oxygen, therefore incapable of supporting the most common kind of biological respiration, or of supporting oxygen-demanding chemical reactions. The deeper waters of a lake may become anoxic if there are many organisms depleting oxygen via respiration, and there is little or no replenishment of oxygen from photosynthesis or from the atmosphere.

Benthic- Referring to the bottom sediments.

Bacterioplankton- Bacteria adapted to the "open water" or "planktonic" zone of lakes, adapted for many specialized habitats and include groups that can use the sun's energy (phytoplankton), some that can use the energy locked in sulfur or iron, and others that gain energy by decomposing dead material.

Bicarbonate- The most important ion (chemical) involved in the buffering system of New Hampshire lakes.

Buffering- The capacity of lakewater to absorb acid with a minimal change in the pH. In New Hampshire the chemical responsible for buffering is the bicarbonate ion. (See pH.)

Chloride- One of the components of salts dissolved in lakewater. Generally the most abundant ion in New Hampshire lakewater, it may be used as an indicator of raw sewage or of road salt.

Chlorophyll a- The main green pigment in plants. The concentration of chlorophyll a in lakewater is often used as an indicator of algal abundance.

Circulation- The period during spring and fall when the combination of low water temperature and wind cause the water column to mix freely over its entire depth.

Density- The weight per volume of a substance. The more dense an object, the heavier it feels. Low-density liquids will float on higher-density liquids.

Dimictic- The thermal pattern of lakes where the lake circulates, or mixes, twice a year. Other patterns such as polymictic (many periods of circulation per year) are uncommon in New Hampshire. (See also meromictic and holomictic).

Dystrophy- The lake trophic state in which the lakewater is highly stained with humic acids (reddish brown or yellow stain) and has low productivity. Chlorophyll a concentration may be low or high.

Epilimnion- The uppermost layer of water during periods of thermal stratification. (See lake diagram).

Eutrophy- The lake trophic state in which algal production is high. Associated with euthrophy is low Secchi disk depth, high chlorophyll a, and low total phosphorus. From an esthetic viewpoint these lakes are "bad" because water clarity is low, aquatic plants are often found in abundance, and cold-water fish such as trout and salmon are usually not present. A good aspect of eutrophic lakes is their high productivity in terms of warm-water fish such as bass, pickerel, and perch.

Free CO2- Carbon dioxide that is not combined chemically with lake water or any other substances. It is produced by repiration, and is used by plants and bacteria for photosynthesis.

Holomixis- The condition where the entire lake is free to circulate during periods of overturn. (See meromixis.)

Humic Acids-Dissolved organic compounds released from decomposition of plant leaves and stems. Humic acids are red, brown, or yellow in color and are present in nearlu all lakes in New Hampshire. Humic acids are consumed only by fungi, and thus are relatively resistant to biological decomposition.

Hydrogen Ion- The "acid" ion, present in small amounts even in distilled water, but contributed to rain-water by atmospheric processes, to ground-water by soils, and to lakewater by biological organisms and sediments. The active component of "acid rain". See also "pH" the symbolic value inversely and exponentially related to the hydrogen ion.

Hypolimnion-The deepest layer of lakewater during periods of thermal stratification. (See lake diagram)

Lake- Any "inland" body of relatively "standing" water. Includes many synonyms such as ponds, tarns, lochs, billabongs, bogs, marshes, etc.

Lake Morphology- The shape and size of a lake and its basin.

Littoral- The area of a lake shallow enough for submerged aquatic plants to grow.

Meromixis- The condition where the entire lake fails to circulate to its deepest points; caused by a high concentration of salt in the deeper waters, and by peculiar landscapes (small deep lakes surrounded by hills and/or forests. (Contrast holomixis.)

Mesotrophy- The lake trophic state intermediate between oligotrophy and eutrophy. Algal production is moderate, and chlorophyll a, Secchi disk depth, and total phosphorus are also moderate. These lakes are esthetically "fair" but not as good as oligotrophic lakes.

Metalimnion-The "middle" layer of the lake during periods of summer thermal stratification. Usually defined as the region where the water temperature changes at least one degree per meter depth. Also called the thermocline.

<u>Mixis</u>- Periods of lakewater mixing or circulation.

<u>Mixotrophy</u>- The lake condition where the water is highly stained with humic acids, but algal production and chlorophyll <u>a</u> values are also high.

<u>Oligotrophy</u>- The lake trophic state where algal production is low, Secchi disk depth is deep, and chlorophyll <u>a</u> and total phosphorus are low. Esthetically these lakes are the "best" because they are clear and have a minimum of algae and aquatic plants. Deep oligotrophic lakes can usually support cold-water fish such as lake trout and land-locked salmon.

<u>Overturn</u>- See circulation or mixis

<u>pH</u>- A measure of the hydrogen ion concentration of a liquid. For every decrease of 1 pH unit, the hydrogen ion concentration increases 10 times. Symbolically, the pH value is the "negative logarithm" of the hydrogen ion concentration. For example, a pH of 5 represents a hydrogen ion concentration of 10^{-5} molar. [Please thank the chemists for this lovely symbolism -- and ask them to explain it in lay terms!] In any event, the higher the pH value, the lower the hydrogen ion concentration. The range is 0 to 14, with 7 being neutral 1 denoting high acid condition and 14 denoting very basic condition.

<u>**Photosynthesis**</u>- The process by which plants convert the inorganic substances carbon dioxide and water into organic glucose (sugar) and oxygen using sunlight as the energy source. Glucose is an energy source for growth, reproduction, and maintenance of almost all life forms.

<u>**Phytoplankton**</u>- Microscopic algae which are suspended in the "open water" zone of lakes and ponds. A major source of food for zooplankton. Common examples include: diatoms, euglenoids, dinoflagellates, and many others. Usually included are the blue-green bacteria.

<u>**Parts per million**</u>- Also known as "ppm". This is a method of expressing the amount of one substance (solute) dissolved in another (solvent). For example, a solution with 10 ppm of oxygen has 10 pounds of oxygen for every 999,990 pounds (500 tons) of water. Domestic sewage usually contains from 2 to 10 ppm phosphorus.

<u>**Parts per billion**</u>- Also known as "ppb". This is only 1/1000 of ppm, therefore much less concentrated. As little as 1 ppb of phosphorus will sustain growth of algae. As little as 10 ppb phosphorus will cause algal blooms! Think of the ratio as 1 milligram (1/28000 of an ounce) of phosphorus in 25 barrels of water (55 gallon drums)! Or, 1 gallon of septic waste diluted into 10,000 gallons of lakewater. It adds up fast!

<u>**Plankton**</u>- Community of microorganisms that live suspended in the water column, not attached to the bottom sediments or aquatic plants. See also "bacterioplankton" (bacteria), "phytoplankton" (algae) and "zooplankton" (mocrocrustaceans and rotifers).

<u>**Saturated**</u>- When a solute (such as water) has dissolved all of a substance that it can. For example, if you add table salt to water, a point is reached where any additional salt fails to dissolve. The water is then said to be saturated with table salt. In lakewater,

gaseous oxygen can dissolve, but eventually the water becomes saturated with oxygen if exposed sufficiently long to the atmosphere or another source of oxygen.

Specific Conductivity- A measure of the amount of salt present in lakewater. As the salt concentration increases, so does the specific conductivity (electrical conductivity).

Stratum- A layer or "blanket". Can be used to refer to one of the major layers of lakewater such as the epilimnion, or to any layers of organisms or chemicals that may be present in a lake.

Thermal Stratification- The process by which layers are built up in the lake due to heating by the sun and partial mixing by wind.

Thermocline- Region of temperature change. (See metalimnion.)

Total Phosphorus- A measure of the concentration of phosphorus in lakewater. Includes both free forms (dissoved), and chemically combined form (as in living tissue, or in dead but suspended organisms).

Trophic Status- A classification system placing lakes into similar groups according to their amount of algal production. (See Oligotrophy, Mesotrophy, Eutrophy, Mixotrophy, and Dystrophy for definitions of the major categories)

Z- A symbol used by limnologists as an abbreviation for depth.

Zooplankton- Microscopic animals in the planktonic community. Some are called "water fleas", but most are known by their scientific names. Scientific names include: Daphnia, Cyclops, Bosmina, and Kellicottia.